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N O T I C E

people were needed. For some kinds of information, the technical people themselves were best qualified to provide these data. Thus we have administered a carefully designed, standardized questionnaire to hundreds of scientists and engineers in a wide variety of laboratories. These questionnaire data have been supplemented by judgments about each man's performance from those well acquainted with his work -- his peers and superiors.

Reported below are data collected in 11 American laboratories by Pelz and myself. University, government, and industrial settings are all represented. Also reported are data from three British industrial labs, collected by Dr. Frederick B. Chaney. In designing his questionnaire, Chaney included some of the same questions which had been used by Pelz and myself, and he generously provided me with a copy of his data for analysis purposes. 2/

In both questionnaires, "colleagues" were defined as other professionals with whom a man worked within the lab. Subordinates who were themselves professionals could be claimed as colleagues, but sub-professional assistants were excluded. Some questions dealing with colleague contact were restricted to a man's most important colleagues -- he could name up to five. Other questions asked about the entire set of colleagues with whom he exchanged useful information.

<u>Frequency of contact with colleagues</u>.

One question which proved interesting was a straightforward item which asked about the <u>frequency</u> with which a man contacted his most important colleagues. In general, the more frequently a man contacted his colleagues, the higher his performance. The exact wording of the question is shown in the box below. Note that contact -- as defined by this item -- could occur by direct conversation, by written memo, or by joint attendance at seminars.

2. Chaney's own analysis appears in F. B. Chaney, "A cross cultural study of industrial research performance," <u>Journal of Applied Psychology</u>, in press.

Question 41. As a general rule, how frequently do you communicate with each of your ... colleagues on work-related matters? (Whether by conversation, memos, seminars, etc.)

[Having named his five most significant colleagues (supervisors were excluded here), the respondent rated the frequency of communication with each using a four-point scale ranging from "Few times a year or less" to "Daily." From these data an average frequency of communication with colleagues was computed for each respondent.]

The results we had first -- for three groups of American scientists -- are shown in Charts 1A to 1C. Although there were some exceptions, the trend in these charts was clear: the performance curves rose as contact increased.

Charts 1A to 1C here

Before one has a full understanding of these charts, however, we need to describe how performance was measured.

Measuring performance. For the American scientists four different measures of performance were examined. Two were based on others' judgments, two on the man's self-reported output. For the first judgment, peers and supervisors who felt knowledgable about a man's work were asked to assess his overall usefulness to the organization over the past five years. (Within the past five years, "to what extent has each person's work been useful or valuable in helping your R & D lab carry out its responsibilities?") Typically, five judges assessed each man's usefulness. Each judge made his assessment independently, and we subsequently combined their answers (which tended to show good agreement) into a single score for "usefulness."

Knowing that some technical people can be making extremely valuable contributions to knowledge even when not being particularly useful to an organization, we also asked each judge to assess how much each man's work had "contributed to general knowledge in his field" over the past five years. Here also the judges were in reasonably good agreement, and we combined their information into a single score on "contribution" for each man. (Not surprisingly, the usefulness and contribution scores tended to show some similarity, but only about half the variation in one could be attributed to the other -- median correlation = .7.)

Several indications of actual output were also examined. Each respondent was asked how many published papers, patents (or patent applications), and unpublished reports he had produced over the past five years. (Various checks -- such as comparing reported output with company records, or with answers to the same question given several months later -- convinced us that respondents were reasonably accurate in reporting their output.) Since technical papers were not a relevant form of output for most engineers, we considered only two forms of output for them: patents and reports. Similarly, we considered only papers and reports for non-engineers. (These output scores were only mildly related to the judgments of performance, and to each other -- median correlation = .2.)

Before we could use the various performance measures in analyses, they needed to be compensated for several background factors, such as the length of a man's professional experience, his seniority in the lab, and the amount of his formal training. Not surprisingly, scientists with long experience, long seniority, and long academic training tended to outperform their younger, less trained colleagues. We wanted to rule out any possibility that these background factors might account for our subsequent results. So appropriate constants were added or subtracted to the performance scores of whole groups to produce a new set of performance scores. These indicated how each person's performance compared with the performance of others who had similar experience, seniority, etc. It is these compensated scores which are plotted in the charts of this article. However, if uncompensated scores had been plotted, the general findings would be the same.

Frequency of contact and performance of American scientists. Having considered the performance measures in some detail, let us return to Charts 1A to 1C. Chart 1A shows data from 73 PhD's in American labs which emphasized development of improved products or processes. All these labs were in either government or industrial settings.

Among these scientists, the average frequency of contact was quite high -- over half contacted each colleague several times a week or more. Chart 1A shows that judgments of technical contribution, judgments of usefulness, and output of reports all were highest for those who had daily contact with each colleague. Output of papers, however, was highest when the scientist contacted his colleagues about weekly.

Chart 1B provides parallel data for 52 PhD's in American research labs -- i.e., labs which emphasized the production of new knowledge. (These happened to be located in university or government.) Here the average frequency of contact was lower -- the median frequency was about weekly. The best performance, however, was shown by those who contacted colleagues semi-weekly or daily.

Data from 199 American "engineers" are shown in Chart 1C. "Engineers" were defined as non-PhD's who worked in development-oriented labs (government or industry) having fewer than 20% PhD's on their technical staffs. Most, but not all of this group had had formal training in engineering. These engineers were like the PhD's in development in that the average frequency of contact was fairly high -- several times a week was typical. Although many engineers claimed average frequencies as high as daily, Chart 1C shows that this may have been too frequent for this group. Semi-weekly contact seemed the optimum amount.

The finding for these scientists in American labs, then, was that those who saw their most important colleagues rather frequently (several times a week or daily) tended to perform at higher levels than those who had less frequent colleague contact. A careful look at Charts 1A - 1C shows that this trend was particularly clear and consistent when performance was measured by the criterion of usefulness.

Would the same results emerge for scientists in British labs? The data collected by Chaney gave us a chance to find out.

Frequency of contact and performance of British scientists. We analysed Chaney's data in a fashion as parallel as possible to the American data. If the British scientists were grouped exactly as the Americans had been, we found two groups well represented. PhD's in development labs and "engineers". (Chaney had not happened to study large numbers of scientists in other groups.)

For both of these groups, Chaney had collected information about their five-year output of publications. He also had asked each man's supervisors and senior-level colleagues to assess his research creativity over the past five years. (Creativity was defined as "that process which results in an original product or idea which is accepted as useful or satisfying at some point in time.") Three to six judges (mean = 5.5) independently assessed the creativity of each man.

As with the data from the Americans, the performance of the British scientists varied systematically with several background factors. So we compensated their scores for differences attributable to age, seniority, and academic degree--factors very similar to those used in compensating the performance scores of the Americans.

Included in Chaney's questionnaire was exactly the same question on frequency of contact with colleagues that had been used previously for American scientists. One marked difference in the answers was immediately apparent. Scientists in these British labs tended to contact their colleagues less frequently than had the Americans. Whereas 57% of the PhD's in the American development labs had average frequencies of semi-weekly or more, only 16% of the PhD's in British development labs scored as high. The typical Briton contacted his most important colleagues only a few times a month. A similar difference between American and British labs appeared for engineers. In American labs 63% of the engineers claimed average frequencies of semi-weekly or more, in British labs the comparable figure was 34%. Clearly the Britons had less frequent professional contacts than comparable groups of American scientists.

What about performance? Was frequent contact associated with high performance in British labs--as it was in American labs? The answer was yes--but with some qualifications. The evidence appears in Charts 1D and 1E.

Charts 1D and 1E here

Chart 1D shows data for 70 PhD's in British development labs. Note that paper production climbed steadily as frequency of contact increased. Ratings of creativity peaked for those with weekly contact (which was above average for these scientists) but then declined when contact was still more frequent.

Among 110 British engineers (see Chart 1E) creativity was highest for those with semi-weekly contact, just as rated usefulness and contribution had been for American engineers. Production of published papers was not much affected by average frequency of colleague contact until it became very high (daily), at which point output of papers dropped sharply. (To be strictly comparable with the analyses for American engineers, we would have preferred to show data for patents in Chart 1E. Although Chaney collected information about output of patent specifications, these were too rare to permit meaningful analysis.)

Thus the general trend in these British labs was similar to what appeared in American labs: the highest performance tended to come from scientists and engineers who contacted their important colleagues rather frequently -- at least weekly and perhaps more often. Daily contact with each important colleague, however, seemed too frequent for engineers, just as it had been in American labs.

Before considering some of the possible explanations and implications of the findings presented so far, there are some other measures of colleague contact worth examining.

Number of colleagues.

Another way of assessing a scientist's contact with colleagues was to inquire about the number of people with whom he exchanged technical information. Data from two questionnaire items were examined. One asked about people in the scientist's own group, the other asked about those he contacted elsewhere in his organization. The exact wording of the items -- which were asked in both American and British labs -- appears in the following box.

Question 28. About how many people in the following situations do you work with closely -- in the sense of exchanging detailed information from time to time that is of benefit to you or to them? (Exclude sub-professional assistants or clerical personnel.)

[In the American labs, respondents checked seven-point scales ranging from "None" to "20 or more" to indicate the number of people "In my immediate groups (sections, projects, teams, etc.)" and "In other technical groups within this organization." In the British labs, respondents indicated the exact number from "0" to "9 or more" "In my department or division," and "In other divisions or departments in this research organization."]

How did these measures of colleague contact relate to each other and to the frequency measure described above? There was a moderate tendency for scientists to exchange information with many colleagues outside their own group (but within their organization) if they also saw many within their own group (median correlation = .4 in American labs, .5 in British labs). Whether this reflected consistency in their behavior (perhaps a professional "sociableness") or exigencies of their work was not clear. Whatever the cause, the positive relationship between the two items was only moderate and we examined each separately.

It was interesting to discover that the total number of colleagues a man worked with was only slightly related to the frequency with which he contacted his most important colleagues (median correlation = .2 in both American and British labs). Thus data about the number of colleagues provided a rather different way of measuring amount of colleague contact. However, in spite of this different way of measuring colleague contact, the previous findings again appeared and are described next.

Performance and number of colleagues in own group. Some results of relating number of colleagues in own group to performance appear in Charts 2A and 2B. Data from all five groups of scientists are shown, but to save space the charts show only the ratings of usefulness for American scientists and the ratings of creativity for British scientists. (Recall that creativity was defined as original ideas which were judged to be useful.) The trends are clear and consistent.

Charts 2A and 2B here

In American labs the scientists who contacted many colleagues in their own group were judged to have done the work which was most useful. Chart 2A suggests that contacts with as many as ten, fifteen, or even twenty or more colleagues were optimum.

Due to a different coding scheme, scientists in British labs who contacted extremely large numbers of colleagues could not be examined separately. In spite of this, the results for British labs shown in Chart 2B are rather similar to those for American labs. For both groups of British scientists, the highest rated creativity was obtained by men who exchanged information with eight or more colleagues in their own group.

The chief difference between Charts 2A and 2B appeared for scientists who contacted very few colleagues in their own group. This was a poor situation in American labs, but neither especially good nor especially poor in British labs.

What about the performance measures not shown in Charts 2A and 2B -- papers, patents, and technical contribution? Their trends were roughly similar to the curves shown, though some were less clear. (There was only one marked exception to the generally rising curves: paper production by PhD's in American development labs was higher for men who contacted few colleagues (0-9) than for those who saw many.)

Performance and number of colleagues outside own group but within organization. Charts 3A and 3B show relationships between scientists' performance and the number of colleagues they exchanged information with outside their own group (but within their organization). As in previous charts, the general finding was that those who had high amounts of colleague contact tended to perform best.

Charts 3A and 3B here

As before, only one measure of performance appears in the charts, but -- with two exceptions -- the trends of the other performance measures were similar. (One of the exceptions occurred for British engineers: published papers declined as the number of outside colleagues increased. The other exception, as in previous charts, occurred for output of papers by PhD's in American development labs.)

By examining the number of cases at the bottom of Charts 3A and 3B one other interesting finding emerges. Scientists in British labs were less likely to contact many (five or more) outside colleagues than were scientists in American labs. This is the same trend as that observed previously for the frequency of contact data: there was less colleague contact in British labs. (This did not appear, however, for the number of colleagues contacted within one's own group; Britons and Americans were about the same in this respect.)

Thus results were remarkably consistent for different groups of scientists, different national settings, and different ways of measuring contact with colleagues. Higher performance tended to go with higher contact.

If this relationship was more than a mere artifact, it suggests that contacts with colleagues may be one important stimulus for high scientific performance. This should have important implications for the way laboratories are organized, and for the way scientists conduct their professional lives. Since the matter seemed important, several possible explanations for these findings have been considered.

Attempts to "explain away" the findings.

Experience. When these results have been presented to technical audiences, one reaction has sometimes been an attempt to attribute them to the operation of some third factor, such as differences in length of experience. The argument is that high performance appeared to go with large amounts of colleague contact simply because the people who had been around longer had had more time to build up both their range of acquaintances and their performance. While this undoubtedly occurred, it could not wholly account for the findings.

The reason the performance scores were compensated for differences in length of experience was precisely so such explanations could be rejected. When the relationships emerged even after the scores had been compensated, they must have been due to something more than just differences in experience.

Role in laboratory. Another argument is that the effect was attributable to differences in laboratory role -- for example, the differences between supervisors and non-supervisors. Supervisors would be expected to have higher performance than the average non-supervisor, and would also be expected to have more contacts with colleagues (colleagues had been defined to include professional-level subordinates). Had these differences accounted for the relationship?

Using data from the American labs, we checked this carefully. The entire analysis was repeated separately for supervisors and non-supervisors. The same upward trends occurred for both subgroups. (Data not shown.) Thus this factor could not account for the relationship.

Causal direction. Still a different possible explanation is that the relationship appeared because high performers were sought out by others and thus achieved their high contact as a result of their high performance. Although this undoubtedly occurred to some extent, two checks suggested it was not the whole story.

Included in the questionnaire administered in American labs was an item which asked how communication with each of the most important colleagues originated. This item appears in the following box.

> Question 43. How does the communication with each person usually originate? Estimate the percent occurring in the following ways, to nearest 5-10%.
>
> [For each of five most important colleagues, the respondents entered percents for the categories that follow.]
>
> I visit or contact him.
> He visits or contacts me.
> We both attend a meeting or seminar.
> Conversation arises spontaneously when we see each other.
> Other ways: ________________

On the basis of the information from this item, scientists were grouped according to the predominant way their contacts originated. (Those whose contacts were likely to originate in any of several ways were omitted.)

One group was composed of scientists who said their contacts with colleagues arose primarily because colleagues came to them. We expected to find positive relations between contact and performance here; and we did. Among this group the better performing scientists were more sought out by colleagues.

Of greatest interest was a group which had indicated that they themselves were primarily responsible for initiating contacts with colleagues. Positive trends between contact and performance appeared here, too. Surprisingly, they tended to be somewhat more marked than for the previous group. Among these contact-initiators, the higher the contact, the higher the performance. Here was important evidence that the relationships we observed were not due simply to others seeking out the higher performing scientists.

Finally, two other groups were examined: those who said contacts arose primarily because both they and their colleagues attended the same seminar, and those who said contacts arose as "unplanned" conversations. In both of these groups we also observed the same positive relationships. Again higher performance tended to go with higher contacts, though these relationships were somewhat less marked than those in the previous two groups.

Taken together, the data from these four subgroups tended to support the hypothesis that contact with colleagues could stimulate performance. Furthermore, they suggested that this was more likely to happen if the contacts were purposefully originated by the people directly concerned -- the man himself or his colleagues -- than if they were unplanned or originated by some third party.

A second check on the causal direction of the relationship between contacts and performance was performed by one of our colleagues, Dr. George Farris. Five years after we had originally measured the performance of scientists and engineers in American labs, Farris went back and obtained information about their performance during the intervening period. He then looked to see whether those who had had higher levels of colleague contact five years previously had subsequently performed better than those with less contact. This was clearly the case when performance was measured by usefulness. Furthermore, he found this same trend even after he allowed for differences in their initial performance levels. Farris concluded that the causal relationship between contact and performance operated in both ways: to some extent, people showed high contact because they were high performers, but it also happened that high performance resulted from high contact. Thus Farris' analyses further supported the idea that contacts can stimulate scientific performance.

Were colleague contacts useful for everyone?

Were there some types of scientists for whom contacts with colleagues would fail to "pay off"? Despite considerable searching of the data from American labs, we found none. Colleague contacts seemed as helpful to people who said they preferred to work alone as to those who preferred working with others. They were as helpful to the man with strong inner motivation as to less motivated men. Even in labs where most work was done autonomously, contacts enhanced performance.

At first the wide usefulness of contacts seemed surprising. We had thought there might be some groups of scientists who -- by reason of their strong motivations, personal preferences, or something else -- would not benefit from contacts. Upon reflection, however, this generally positive trend seemed reasonable.

Reasons contacts may have helped.

We could only speculate on what may have been going on, but there seemed to be a number of reasons why contacts might have been beneficial. One, of course, was simply providing new ideas -- jostling a man out of his old ways of thinking. But colleagues may have done much more. Sometimes a colleague may have known something another man needed to know: "Hook it to the red terminal and wait ten minutes," or "Go see Fred, he knows all about it." Other times important coordination may have occurred: "Why not ask Ruth to run it for you; I'm not keeping her too busy right now."

Also there was the possibility of a colleague catching an error which the man himself was too engrossed to see: "You're crazy, Joe, the company couldn't possibly afford to produce it." Or knowing that even one other person thought a problem worth working on may have been all it took to keep a man going in a new area: "It would be great if you could solve that one!"

Still another way colleague contact may have helped was in keeping a man on his toes — putting in a good day's work, or running a test the way it should have been run, or providing some friendly (but nevertheless real) competition for promotion or recognition.

In short, it may be a mistake to think of contacts with colleagues as having provided only intellectual stimulation and new ideas. There may have been a lot of error catching, coordination, and maybe even some needed relaxation: "Come on, John, you can't win them all; let's get some coffee." For these, and perhaps other reasons, it seemed reasonable that contacts could be useful to a great variety of technical people.

Optimum forms of contact.

If contacts could stimulate performance, did it matter how they occurred? Several analyses performed on the data from American labs shed light here.

One has already been briefly described. We found contacts were more related to performance when they were originated by the people directly concerned than if unplanned or originated by a third person. This seemed to make good sense.

Numerous other questions came to mind. If a man saw many colleagues within his own group, did it matter how many he saw outside? If he saw his most important colleagues frequently, did it matter how long he spent communicating with them? By taking the various measures of colleague contact in pairs and examining the combined effects, these questions could be answered.

The three contact measures discussed above -- frequency, number of colleagues within the group, and number outside -- seemed to have stimulating properties which "accumulated." Performance was higher if a person scored high on two of these measures than if he scored high on just one. Thus frequent contact with many colleagues was preferable to frequent contact with just a few (and the lowest performance of all came from those who saw only a few colleagues and those rarely). Similarly, having many colleagues in one's own group and many colleagues in other local groups was preferable to having many colleagues in one's own group only, or in other local groups only.

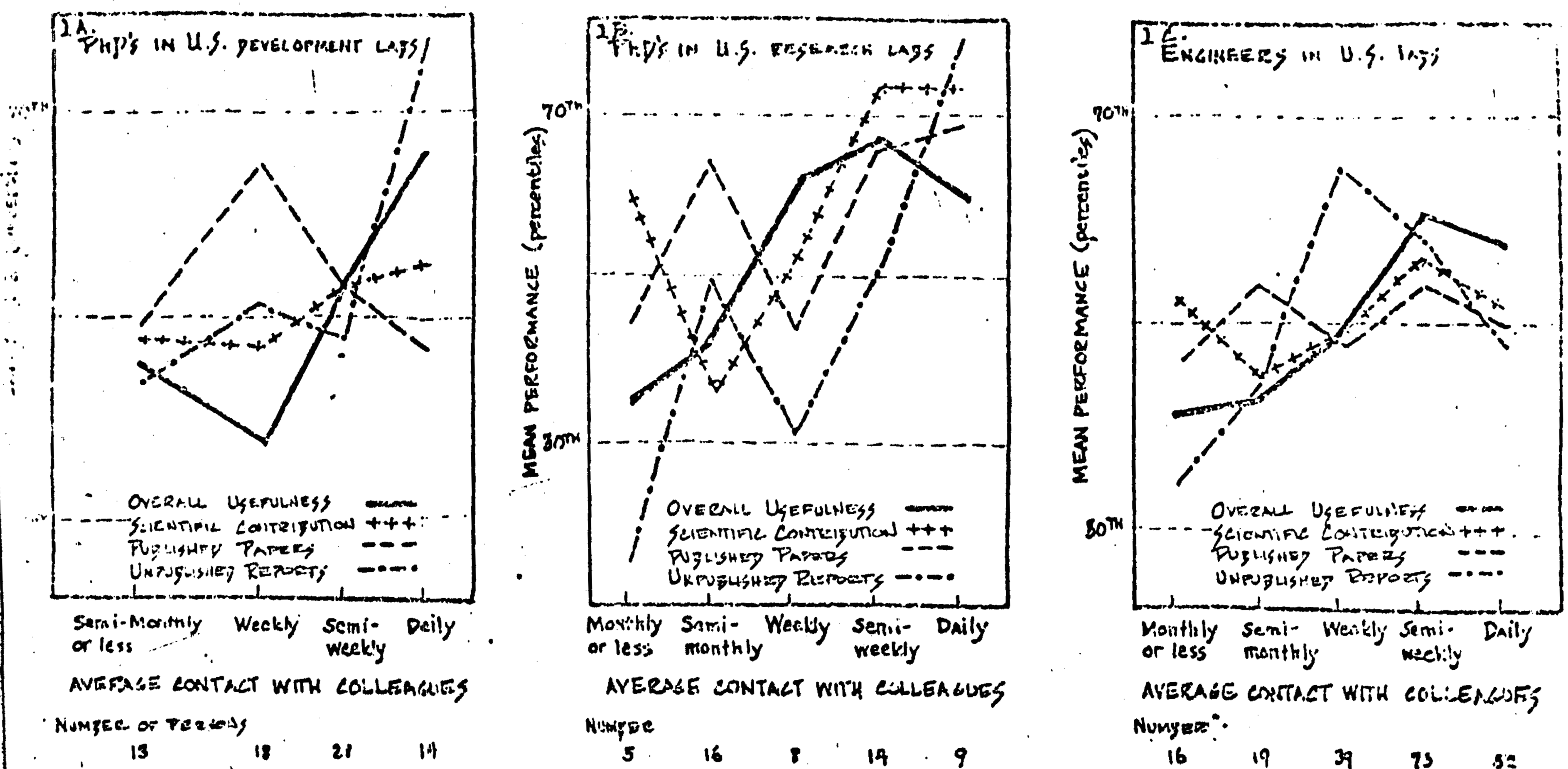
A fourth measure of colleague contact, not discussed previously, asked about the amount of time a man spent communicating with his most important colleagues. In the American labs (the only groups for which the data were available) the previously observed contact-performance relationship held -- the more time spent communicating, the higher the performance. (Optimum times were 6–10 hours per week per colleague for PhD's, 8–15 hours for engineers. Of course, several colleagues might have been contacted simultaneously.) But it was discovered that the other indications of colleague contact were especially important for scientists who spent relatively little time communicating. For scientists who averaged fewer than three hours per week contacting each important colleague, it was especially important to have frequent contacts and to contact many colleagues. However, for those scientists who averaged three or more hours per colleague each week, the frequency of contacts and the number of colleagues was less important.

Thus it appeared that there were several different paths to effective interaction. Spend much time on communication (in which case the other factors did not seem to matter), or spend little time but contact many people frequently. The situation to be avoided, apparently, was that of spending little time on infrequent contacts with few colleagues!

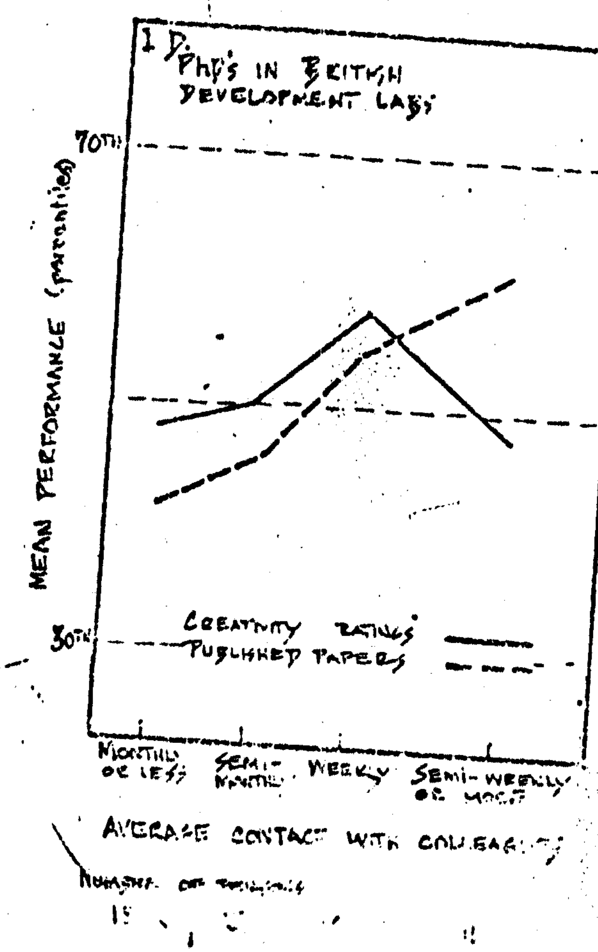
In conclusion

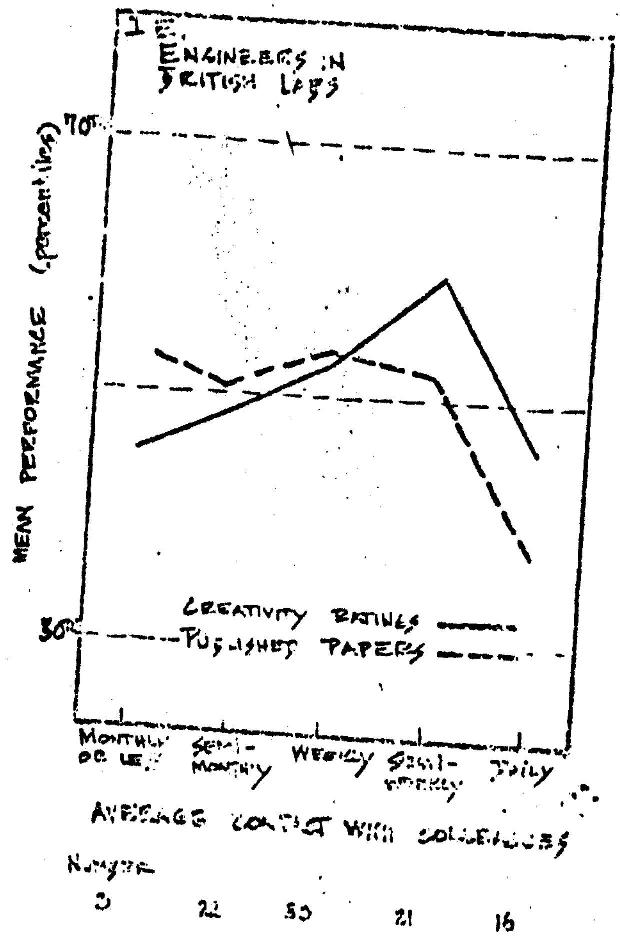
Of the many factors which affect creativity and scientific performance, social psychological aspects of the laboratory environment are particularly interesting and important because they can be influenced -- at least to some extent -- rather rapidly. Among the social psychological factors, contact with colleagues seemed to be one which stimulated technical performance -- for a variety of different types of scientists and engineers, and in both British and American laboratories.

Donald Pelz and I have identified certain other factors and conditions which seem to stimulate performance in American labs. A forthcoming book, Scientists in Organizations: Productive Climates for Research and Development (due for publication by John Wiley, Inc. in Nov. 1966) describes our investigations. There is a strong need, however, to determine whether those and other factors would stimulate creativity by technical people in other cultures. The issue is ripe for investigation.

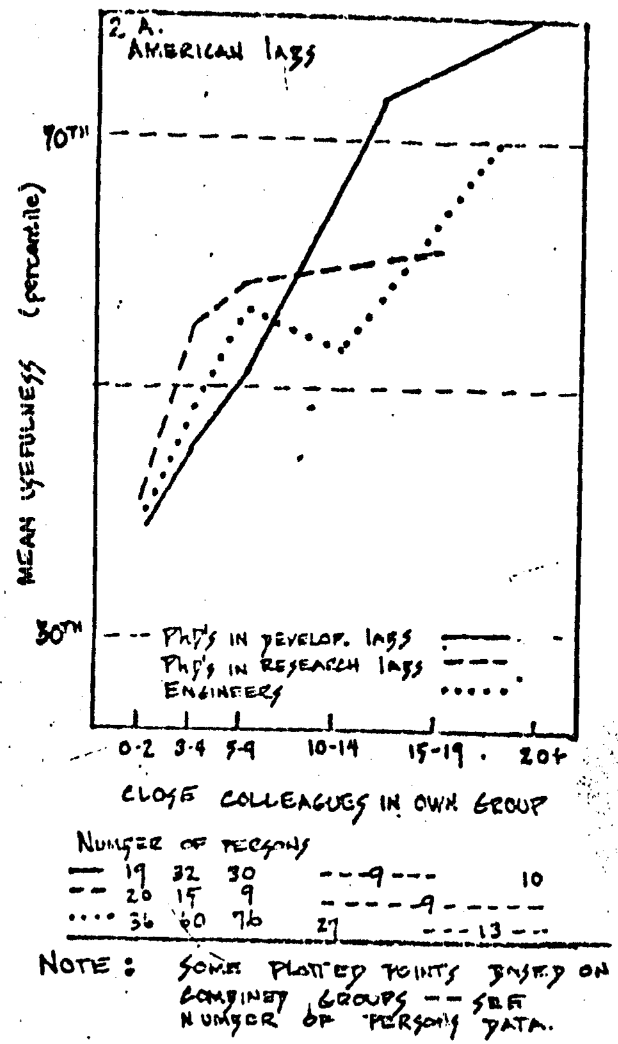


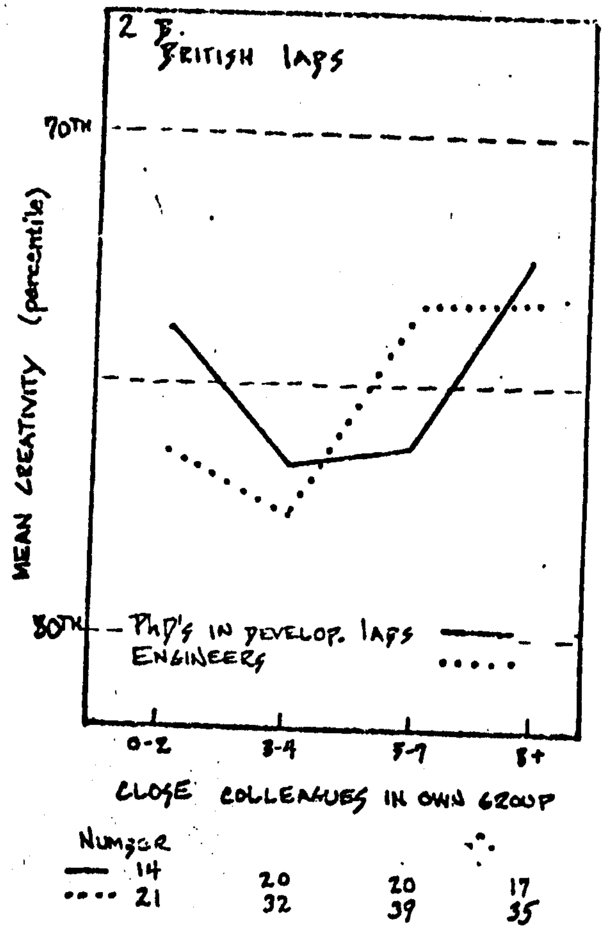
Charts 1A to 1C. FREQUENT CONTACT WITH IMPORTANT COLLEAGUES was characteristic of high performers among these three groups of scientists in American labs. For PhD's in development labs, the optimum frequency was daily for three of the four performance measures. For PhD's in research, performance was better with semi-weekly or daily contact than with lower frequencies. For engineers, the optimum frequency was semi-weekly for most measures of performance.



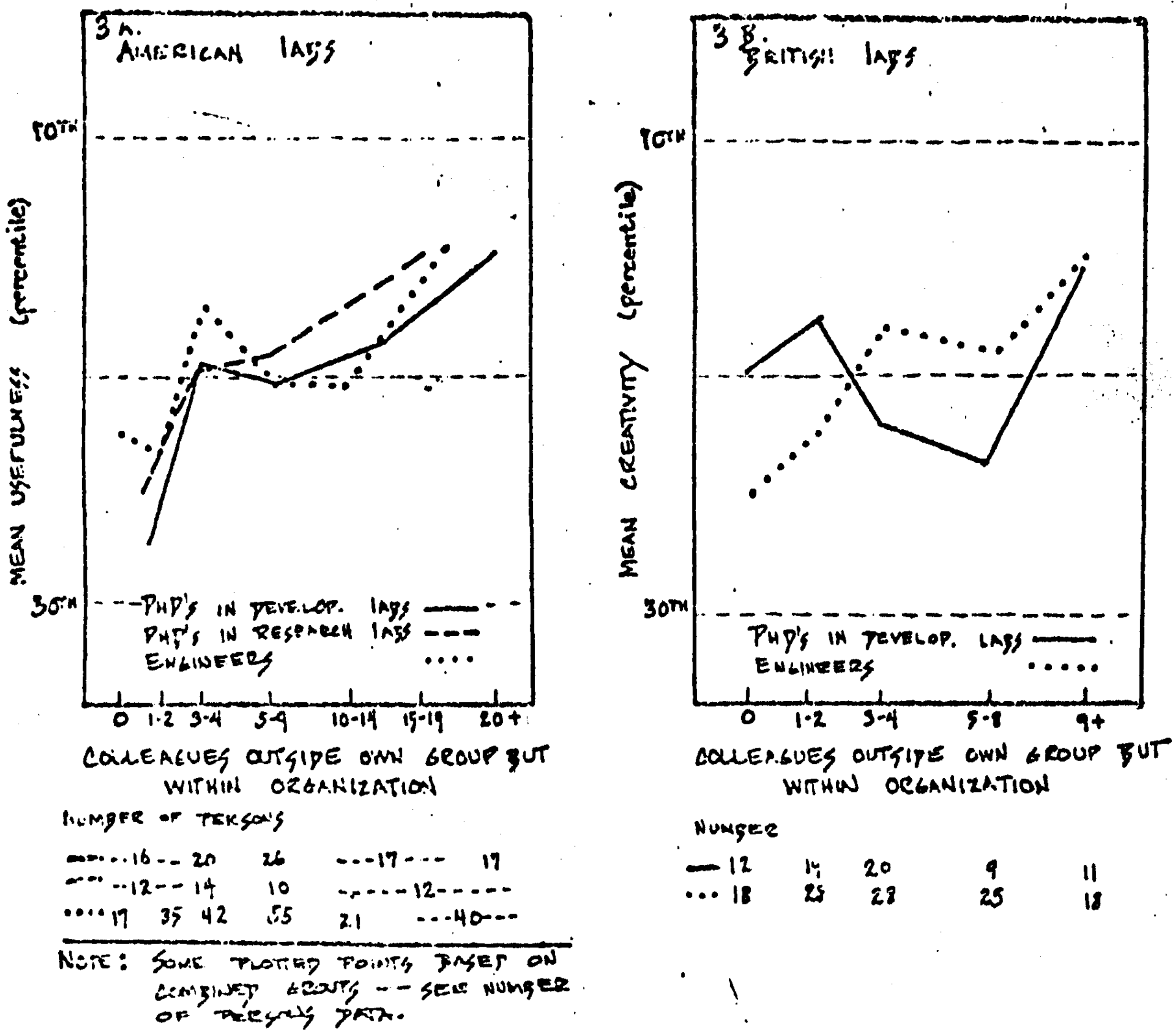


Charts 1D and 1E. IN BRITISH LABS the best performance came from scientists who contacted their most important colleagues about 1-2 times per week--a frequency which was substantially above average. But daily contact was clearly too frequent for engineers.





Charts 2A and 2B. NUMBER OF COLLEAGUES IN OWN GROUP also related to a man's usefulness or creativity. In both American and British labs, the highest performance came from those who exchanged technical information with many persons. Britons, however, did moderately well if they contacted only 0-2 others. Although only one rating for each group is shown here, trends were similar for most other indications of performance.



3A and 3B. COLLEAGUES OUTSIDE THE SCIENTIST'S GROUP but within his organization provided still
t indication of colleague contact. As with other contact measures, scientists who had high con-
ere consistently judged most useful or creative.

Author

Dr. Frank M. Andrews (Contacts with Colleagues and Scientific Performance) is Study Director in the Organizational Behavior Program at the Survey Research Center, University of Michigan, and Lecturer in the Department of Psychology, University of Michigan. His research has focused on how social and organizational factors affect scientific performance and creativity. A book by Pelz (Donald C.) and Andrews, Scientists in Organizations: Productive Climates for Research and Development, describes results of a major quantitative investigation of scientists and engineers and is due for publication next month.

FURTHER READING:

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